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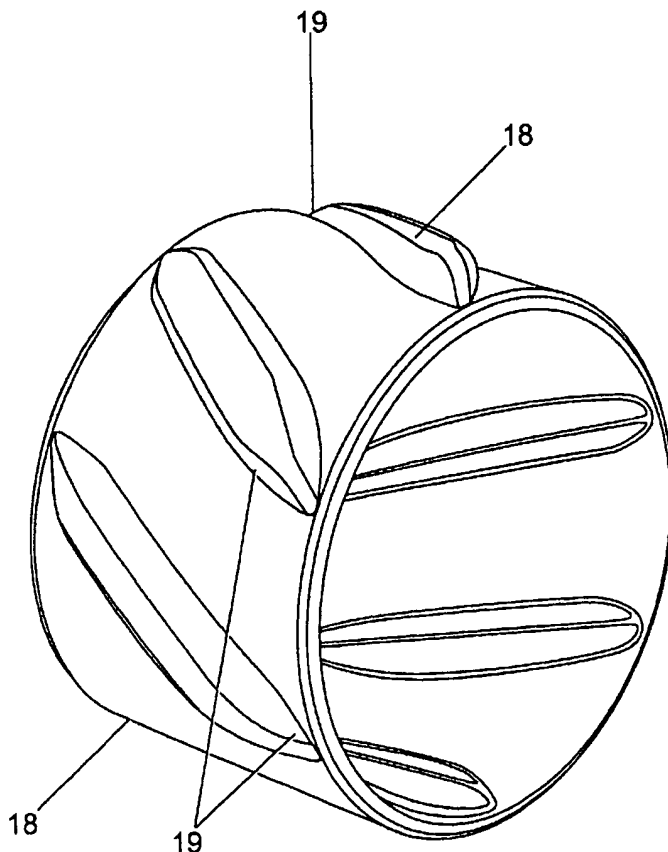
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(54) Title: CENTRALISER



(57) Abstract: A centraliser for use in centralising casing or other tubulars such as tubulars in an oil or gas well comprising an annular body with a bore extending through the body and one or more blades, the centraliser being adapted to fit around a tubular to be centralised, and comprising a tempered metal such as austempered ductile iron (ADI).

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

1     **"Centraliser"**

2

3     This invention relates to a centraliser, and  
4     particularly to a centraliser for use in  
5     centralising casing or other tubulars such as  
6     drillpipe or screens in an oil or gas well.

7

8     In drilling wellbores for oil and gas it is common  
9     to drill through the formation and subsequently to  
10    case the open bore with a liner or a casing  
11    (typically of metal) and to cement the liner or  
12    casing in place. Centralisers are used around the  
13    liner or casing in order to keep it in the middle of  
14    the borehole and to allow free flow of cement  
15    through the annulus between the casing and the wall  
16    of the borehole. This acts as a sealant and also as  
17    a mechanical support for the casing. Centralisers  
18    have therefore been adapted for attachment around  
19    the outer diameter of a liner or casing prior to the  
20    cement job. Centralisers can also be used to keep a  
21    screen in a central location in the wellbore as it  
22    passes through a formation.

1 According to the present invention there is provided  
2 a centraliser comprising an annular body with a bore  
3 extending through the body and one or more blades,  
4 the centraliser being adapted to fit around a  
5 tubular to be centralised, and comprising a tempered  
6 metal.

7  
8 The invention also provides a method of  
9 manufacturing a centraliser, the method comprising  
10 forming the centraliser from metal and tempering the  
11 metal centraliser.

12  
13 The metal is preferably austenitised, typically by  
14 heating the metal to 800-960°C typically for 1 to 4  
15 hours. Preferably the metal is also austempered by  
16 quenching in molten salt for 2-4 hours at 200-400°C  
17 and preferably air dried. Preferably the salt is a  
18 mixture of potassium nitrate and sodium nitrite.  
19 Typically an equimolar mixture of these salts is  
20 used. Typically the entire centraliser is formed  
21 from the tempered metal. Any other tempering  
22 process can be used to temper the metal. Suitable  
23 methods can be found in Metals Handbook Vol 1-3  
24 1990-1991 published by ASM International.

25  
26 The metal is preferably ductile metal and most  
27 preferably comprises ductile iron, although any  
28 metal that can be tempered will suffice. Castable  
29 metals are preferred.

30

1 Alloys can be used as the metal of the centraliser,  
2 and in particular, iron can be alloyed with Mo, Cu  
3 or Ni to enhance the hardness of the metal.

4  
5 The iron is normally a cast iron with preferably  
6 3.2-3.8% C (most preferably around 3.6% C) and 2.2-  
7 2.8% Si (most preferably around 2.5%). Typically  
8 other alloying elements are added in very small  
9 quantities (<0.04%) which may include Mg, Mn, Cu,  
10 Ni, Mo, Sn, Sb, P, S, O, Cr, Ti, V, Al, As, Bi, B,  
11 Cd, Pb, Se, Te. Elements such as Be, Ca, Sr, Ba, Y,  
12 La, Ce may be added in lieu of, or in addition to,  
13 Mg.

14  
15 Grades 1-5 of ADI are preferred according to  
16 ASTM 897M-90.

17  
18 The centraliser is typically cast into the desired  
19 shape with the annular body and blades, optionally  
20 shaped e.g. by filing or grinding, and then  
21 tempered, e.g. by austempering the whole  
22 centraliser. The tempering process can be extended  
23 in accordance with the ratio of ferrite:pearlite in  
24 the metal. Metals with a higher ferrite:pearlite  
25 ratio may need longer tempering process times. The  
26 centraliser is typically cast in a slightly  
27 different shape (e.g. with an oval-shaped annular  
28 body) to that of the final product (e.g. a  
29 cylindrical annular body) to allow for distortions  
30 occurring during the casting and tempering process.  
31 Typically the centraliser shrinks by e.g. 1-2%  
32 during casting and typically expands by e.g. 1-2%

1 after heat treatment. Therefore the centraliser is  
2 typically cast to a different size than finally  
3 required.

4  
5 The blades are preferably circumferentially  
6 distributed around the outer surface of the  
7 centraliser, and preferably each extends parallel to  
8 the bore of the centraliser. The blades are  
9 preferably disposed opposite one another on the  
10 centraliser body. There may be four, five or six  
11 such blades or some other number.

12  
13 The method of the invention is typically carried out  
14 by high-temperature casting in a sand casting mould.  
15 The blades of the centraliser are typically formed  
16 between indentations in the mould and protrusions on  
17 a blank set in the mould. The blade shapes are  
18 typically profiled to facilitate removal of the cast  
19 centraliser from the mould, and are typically  
20 profiled differently from one another. The  
21 centraliser is typically formed by two half-moulds  
22 adapted to engage one another so as to form the  
23 centraliser between the two half-moulds. Typically  
24 the join between the two moulds is aligned with a  
25 blade of the centraliser.

26  
27 The tubular can be drillpipe, casing, liner,  
28 production tubing, coil tubing and may include  
29 slotted and predrilled and/or plugged tubing,  
30 screens and perforating strings etc for disposal in  
31 the reservoir payzone, in which case the centraliser

1 would maintain the screen in the middle of the  
2 uncased borehole.

3

4 An embodiment of the invention will now be described  
5 by way of example and with reference to the  
6 accompanying drawings in which:-

7 Fig. 1 is a front elevation of a centraliser;

8

9 Fig. 2 is a side perspective view of the Fig.  
10 1 centraliser;

11

12 Fig. 3 is a plan view of the Fig. 1  
13 centraliser; and,

14

15 Fig. 4 is a perspective exploded view of a  
16 sand cast used to manufacture the Fig. 1  
17 centraliser.

18

19 A casing centraliser 10 comprises a unitary moulded  
20 cylindrical body 12, and an array of six  
21 equiangularly-spaced blades 14 integrally formed  
22 with the body 12. A cylindrical bore 16 extends  
23 axially through the body 12, and has a substantially  
24 uniform diameter dimensioned to be a clearance fit  
25 around the well bore casing, or other tubular to  
26 which the centraliser is applied.

27

28 Each of the blades 14 not only extends between  
29 longitudinally opposite ends of the body 12, but  
30 also extends circumferentially around the periphery  
31 of the centraliser 10. The skewing of the blades 14  
32 ensures that their respective outer edges 18

1 collectively provide a generally uniform well bore-  
2 contacting surface around the circumference of the  
3 centraliser 10.

4  
5 Each of the blades 14 has a respective radially  
6 inner root 19 integral with the body 12. In each of  
7 the blades 14, the root 19 has a greater  
8 circumferential width than the outer edge 18, i.e.  
9 the cross-section of each blade 14 tapers towards  
10 the well bore-contacting periphery of the  
11 centraliser 10. The individual and collective  
12 shapes of the blades 14, and of the longitudinal  
13 fluid flow passages defined between adjacent pairs  
14 of the blades 14, gives the centraliser 10 improved  
15 flow characteristics and minimises the build-up of  
16 trapped solids during use of the centraliser 10.  
17 The tapered cross-section of the blades also eases  
18 removal of the centraliser from the cast during  
19 manufacture.

20  
21 Longitudinally opposite ends of the blades 14 and of  
22 the body 12 are chamfered to assist in movement of  
23 the centraliser 10 up/down a well bore.

24  
25 The blades 14 of the centraliser 10 keep the tubular  
26 centralised within the borehole, and bear against  
27 the wall of the borehole to reduce friction should  
28 the tubular be moved.

29  
30 It is preferred that the entire centraliser 10 be  
31 fabricated as a one-piece article (although the  
32 blades 14 could be separately formed and



1 subsequently attached to the body 12 by any suitable  
2 means). The centraliser 10 is typically formed from  
3 ductile iron and moulded in a sand cast 20.

4  
5 The sand cast 20 is used to cast mould the  
6 centraliser 10. The sand cast 20 is made up from two  
7 parts 21a, 21b with semi-circular cross section.

8  
9 An indent 22 to correspond to the outer face of the  
10 centraliser 10 is first cut out from the sand 25 in  
11 each part 21a, 21b of the cast 20. Further  
12 indentations are then cut into the indent 22 to form  
13 outer faces of blades 14 in the cast centraliser.

14 An inner core 23 is secured in support holes 24 to  
15 act as a blank and is suspended in the indent 22  
16 without touching the walls thereof so as to displace  
17 metal from an axial bore of the centraliser 10 and  
18 provide on its outer surface a blank for the inner  
19 surface of the centraliser 10. The core 23 is  
20 therefore located in the mould where the bore 16 of  
21 the centraliser will be in the finished article.

22 The upper cast 21b is joined to the lower cast 21a  
23 before the metal is poured so that the complete  
24 shape cut out of the sand 25 is that of the  
25 centraliser 10. Normally the join between the upper  
26 21b and lower 21a parts of the cast are aligned with  
27 or are close to a blade 14.

28  
29 As the material will shrink on cooling and its  
30 dimensions will be altered during heat treatment,  
31 the shape of the indent 22 can first be precisely  
32 determined from shrinkage calculations and by

1 measurements of previous casts. The material being  
2 moulded will also affect the shrinkage  
3 characteristics. Typically the centraliser will  
4 expand during the tempering process. As the  
5 shrinkage after casting and particularly the  
6 expansion after tempering, is non-uniform a  
7 specifically calculated indent 22 is used to make  
8 the centraliser 10. We find that ductile iron  
9 shrinks by about 1-2% when cooling in the cast, and  
10 expands by about 1-2% when being tempered.

11  
12 The sides of the indent 22 curve inwards to allow  
13 the mould to be removed from the centraliser after  
14 the material has solidified. The blades 14 are  
15 tapered to ease the removal of the centraliser 10  
16 from the mould.

17  
18 Molten ductile iron is poured through the hole 26  
19 and into the indent 22. The iron is allowed to cool  
20 and so the centraliser 10 is formed. The sand cast  
21 20 can then be removed from the centraliser 10. The  
22 tapered sides of the indent 22 and tapered blades 14  
23 allow the cast to be removed relatively easily.

24  
25 The iron is normally a cast iron with between 3.2-  
26 3.8% C (most preferably 3.6% C) and 2.2-2.8% Si  
27 (most preferably 2.5%). C and Si to an extent,  
28 encourage similar properties in the material and so  
29 the sum of %C, and  $(1/3) \%Si$  can be considered as a  
30 carbon equivalent(CE). The total CE ranges are  
31 typically around 4.3% for thick sections (over 2"),

1 to 4.6% for thin sections, (0.1"-0.5"), but other  
2 values can be used.

3  
4 Optionally other alloying elements are added in very  
5 small quantities which may include Mn (typically  
6 0.35-0.60%), Mg ( $(\%S \times 0.76) + 0.025\% \pm 0.005\%$ ),  
7 Sn (0.02  $\pm$  0.003%), Sb (0.002%  $\pm$  0.0003%), P  
8 (0.04%), S (0.02%), O (50ppm), Cr (0.10%),  
9 Ti (0.040%), V (0.10%), Al (0.050%), As (0.020%), Bi  
10 (0.002%), B (0.002%), Cd (0.005%), Pb (0.002%), Se  
11 (0.030%), and/or Te (0.020%).

12  
13 To increase hardenability for a heavier section  
14 (i.e. greater than 19mm), Cu (up to 0.8%), Ni (up to  
15 2%) and Mo (up to 0.3%) may be added. Increased  
16 hardenability helps to prevent the formation of  
17 pearlite during quenching. Mg is added to encourage  
18 nodulisation. Elements such as Be, Ca, Sr, Ba, Y,  
19 La, Ce may be added in lieu of or in addition to Mg.  
20 The total weight of nodulising elements is not  
21 normally more than about 0.06%.

22  
23 The castings should be free of non-metallic  
24 inclusions, carbides, shrink and dross. Proper  
25 purchasing, storage and use of charge material will  
26 minimise the unwanted occurrence of carbides and gas  
27 defects. Proper moulding control will minimise  
28 surface defects and other sub-surface  
29 discontinuities. The casting should be properly  
30 gated and poured using consistent and effective  
31 treatment and inoculation techniques to ensure  
32 shrink free castings. Preferably the nodule count

1 will be at least 100/mm<sup>2</sup> and the nodularity at least  
2 85%.

3  
4 After casting the centraliser 10 is tempered by a  
5 heat treatment to produce a stronger, harder  
6 material. The ductile iron used to produce the  
7 centraliser 10, normally contains pearlite and  
8 ferrite which are irregular in shape and vary  
9 substantially in size. This reduces hardness and  
10 strength. The centraliser is heated to the  
11 austenite phase i.e. between 815°C and 955°C  
12 depending on the precise concentration of the  
13 alloys. The centraliser is held for 1-4 hours in  
14 the austenite phase, the precise time required  
15 depends on the size of the centraliser and the  
16 amount of ferrite in the metal; a higher  
17 concentration of ferrite may require more time at  
18 these elevated temperatures. When the austenite is  
19 saturated with carbon the centraliser is then  
20 austempered. To achieve this the metal is  
21 quenched in molten salt at 240°C - 400°C. The rate  
22 of cooling should be sufficient to avoid the  
23 formation of ferrite or pearlite. The metal is held  
24 in the salt for 1-4h to allow the austenite to  
25 change to ausferrite. The molten salt is normally  
26 an equimolar mixture of potassium nitrate/sodium  
27 nitrite although other salts may be used.

28  
29 The net effect of the heat treatment is to cause the  
30 ferrite and pearlite phases to be converted into  
31 ausferrite. Ausferrite is a stabilised carbon  
32 enriched austenite and acicular ferrite non-

1 equilibrium phase. The resulting material is termed  
2 austempered ductile iron (ADI).

3

4 This material is twice as strong as conventional  
5 ductile iron. Another advantage is that this  
6 material is less dense than conventional steel and  
7 so is up to 10% lighter. A further advantage is the  
8 increased hardenability compared with steel. The  
9 cost of manufacturing in this way is also reduced.

10

11 Alternatively, other heat treatments may be used to  
12 adapt the microstructure and phase composition of  
13 the metal 22.

14

15 For example to increase ductility the material may  
16 be heated up to 700-730°C. After 1-4 hours the  
17 material is quenched in molten salt. This reduces  
18 the amount of coarse pearlite and increases the  
19 amount of spheroidite in the structure.

20

21 A further alternative may be to anneal the steel.  
22 The centraliser is again heated into the austenite  
23 phase but is then allowed to cool gradually. This  
24 produces a microstructure with small and uniform  
25 grains.

26

27 Modifications and improvements can be incorporated  
28 without departing from the scope of the invention.

29

1     Claims

2

3     1.    A centraliser comprising an annular body with a  
4     bore extending through the body and one or more  
5     blades, the centraliser being adapted to fit around  
6     a tubular to be centralised, and comprising a  
7     tempered metal.

8

9     2.    A centraliser as claimed in claim 1, wherein  
10    the centraliser is made substantially from a  
11    tempered metal.

12

13    3.    A centraliser as claimed in any preceding  
14    claim, wherein the metal is ductile iron.

15

16    4.    A centraliser as claimed in any preceding  
17    claim, wherein the tempered metal is austempered  
18    ductile iron.

19

20    5.    A centraliser as claimed in any preceding  
21    claim, wherein the metal comprises 3.2-3.8wt% C  
22    and/or 2.2-2.8wt% Si.

23

24    6.    A centraliser as claimed in any preceding  
25    claim, wherein the metal is alloyed with at least  
26    one of Mo, Cu and Ni.

27

28    7.    A centraliser as claimed in any preceding  
29    claim, wherein the metal is alloyed with at least  
30    one of Mg, Mn, Sn, Sb, P, S, O, Cr, Ti, V, Al, As,  
31    Bi, B, Cd, Pb, Se, Te, Be, Ca, Sr, Ba, Y, La, and  
32    Ce.

1     8.    A centraliser as claimed in any preceding  
2     claim, wherein the blades are circumferentially  
3     distributed around the outer surface of the  
4     centraliser, each extending parallel to the bore of  
5     the centraliser.

6

7     9.    A method for manufacturing a centraliser, the  
8     method comprising forming a centraliser from metal  
9     and tempering the metal centraliser.

10

11    10.   A method as claimed in claim 9, wherein the  
12    centraliser is a centraliser as claimed in any one  
13    of claims 1 to 8.

14

15    11.   A method as claimed in claim 9 or claim 10,  
16    wherein the method comprises the steps of:-

17        heating a ductile iron centraliser to a first  
18    temperature at which austenite is formed;

19        maintaining the centraliser at said  
20    temperature; and

21        cooling the centraliser to room temperature.

22

23    12.   A method as claimed in claim 11, wherein the  
24    method also includes cooling the centraliser from  
25    the first temperature to a second temperature at  
26    which austempering may take place, before cooling  
27    the centraliser to said room temperature.

28

29    13.   A method as claimed in claim 12, wherein the  
30    centraliser is quenched from the first temperature  
31    to the second temperature.

1 14. A method as claimed in any one of claims 11 to  
2 13, wherein the centraliser is cooled at a rate  
3 sufficient to combat the formation of ferrite and  
4 pearlite.

5  
6 15. A method as claimed in any one of claims 9 to  
7 14, wherein at least some of the steps are performed  
8 in a sand casting mould.

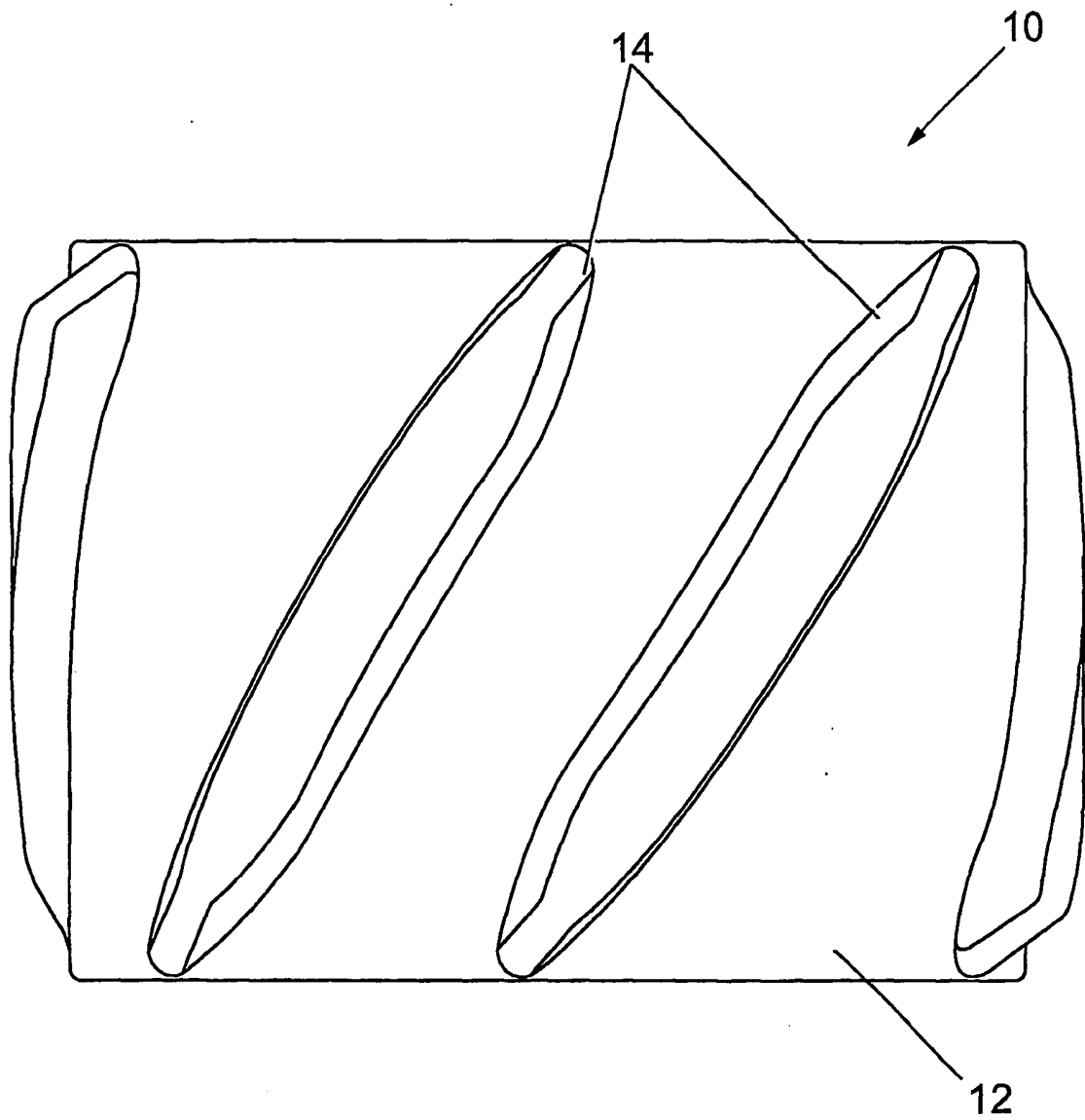
9  
10 16. A method as claimed in claim 15, wherein the  
11 blades of the centraliser are formed between  
12 indentations in the mould and protrusions on a blank  
13 set in the mould.

14  
15 17. A method as claimed in claim 15 or 16, wherein  
16 the blade shapes are profiled to facilitate removal  
17 of the cast centraliser from the mould.

18  
19 18. A method as claimed in any one of claims 15 to  
20 17, wherein the join between the two moulds is  
21 aligned with a blade of the centraliser.

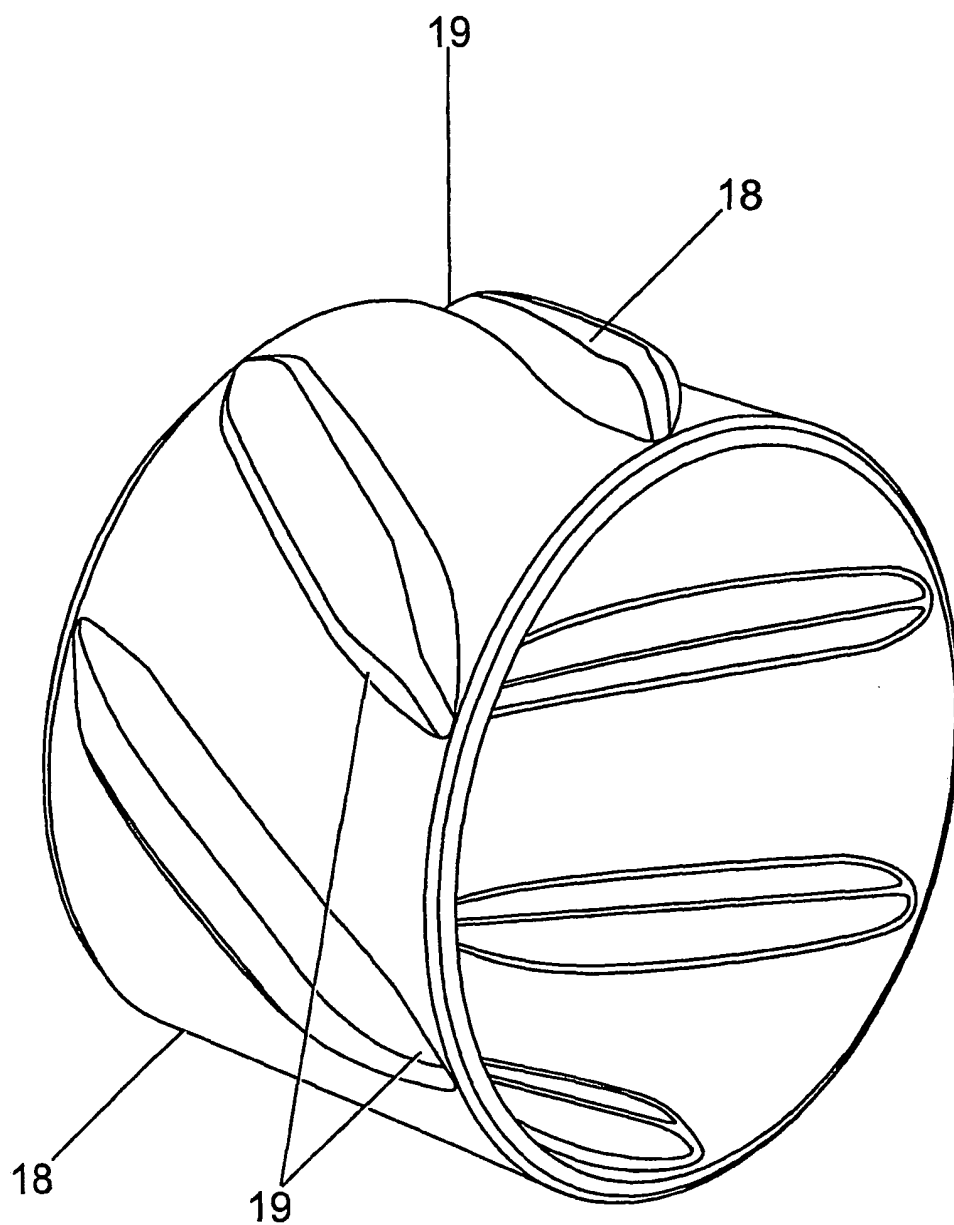


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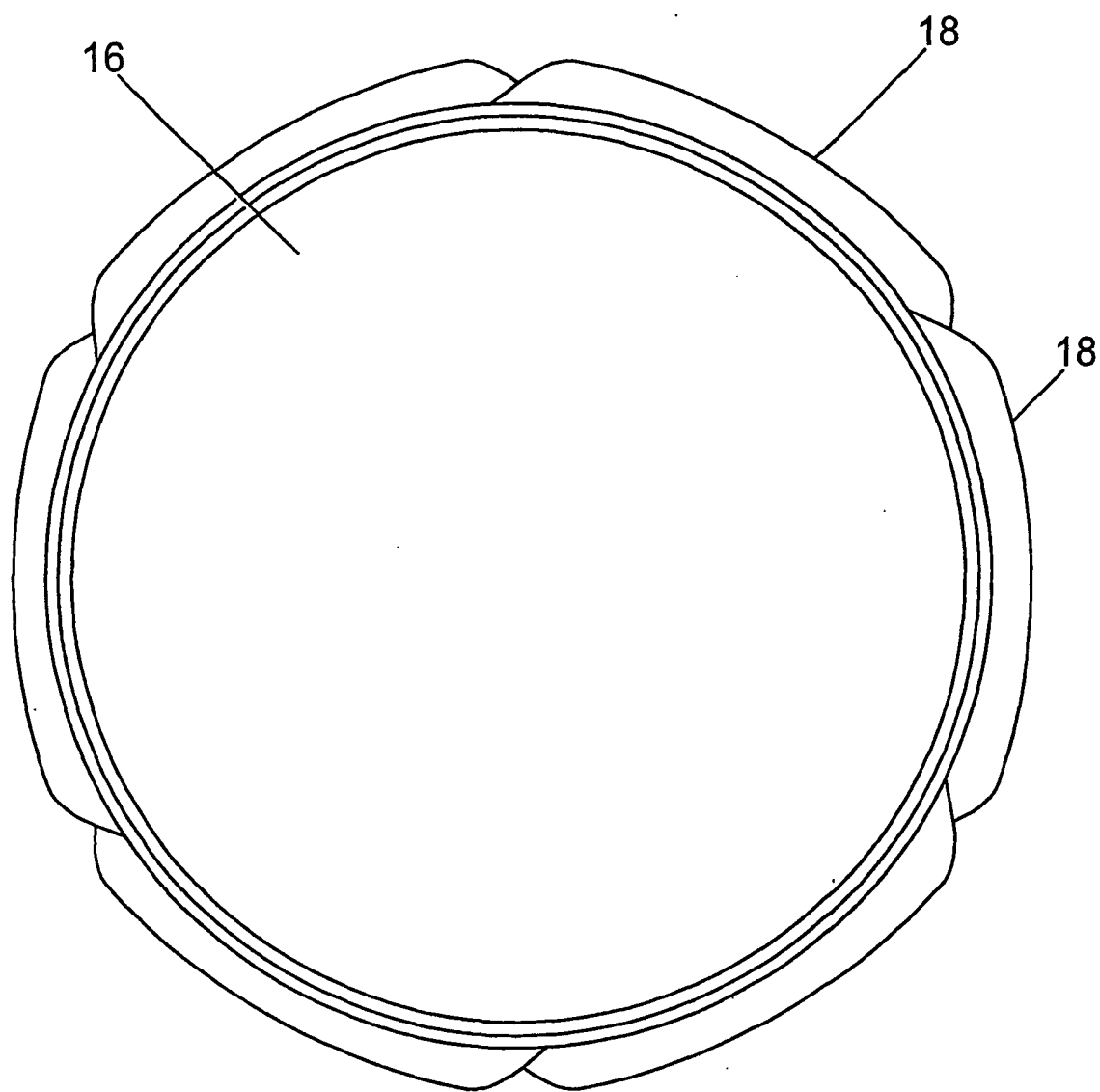
*Fig. 1*

2 / 4



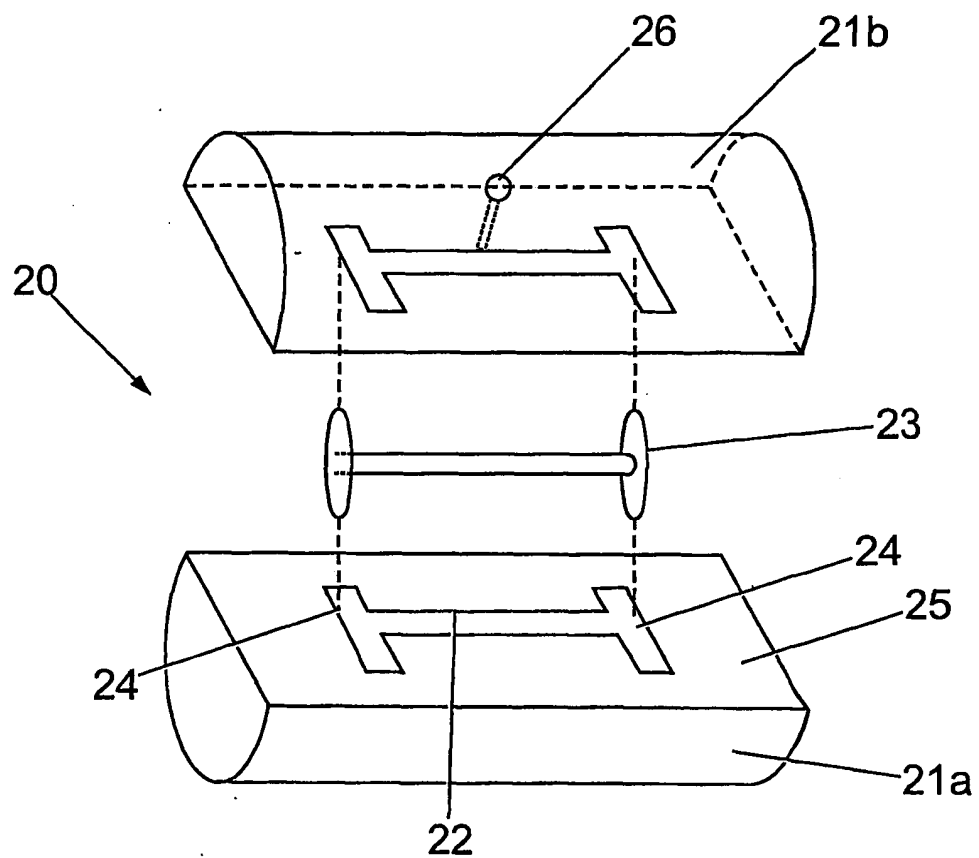
*Fig. 2*

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*Fig. 3*

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*Fig. 4*

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 E21B17/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 937 948 A (ROBBINS) 17 August 1999 (1999-08-17) abstract	1,9



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

8 August 2001

Date of mailing of the international search report

17/08/2001

Name and mailing address of the ISA

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